# Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

BIBLIOGRAPHY

R. H. Biffen.
  1915. Mendel's Laws of Inheritance and Wheat Breeding. *Journal of Agric. Science,* Cambridge.
J. Grancher and J. Comby.
  1904. Maladies de l'enfance, Paris.
A. L. Hagedoorn.
  1911. Autokatalytic Substances the Determinants for the Inheritable Characters. Roux' series Aufsätze und Vort., Leipzig.
  1914. Ratten. De Levende Natuur, Amsterdam.
W. Von Leube.
  1908. Spezielle Diagnose der Inneren Krankheiten, Leipzig.
C. C. Little.
  1917. Evidence of Multiple Factors in Mice and Rats. AMER. NAT.
W. A. Orton.
  1911. The Development of Disease Resistant Varieties of Plants. Comptes Rendus Conférence de Génétique, Paris.
E. E. Tyzzer.
  1909. A Study of the Inheritance in Mice with Reference to their Susceptibility to Transferable Tumors. *Journal Med. Research.*

# NOTE ON THE PHOTIC SENSITIVITY OF THE CHITONS[1]

1. The remarkable sensory organs discovered by Mosely (1885) in the tegmentum of the shell-valves of certain chitons are structurally of such a nature that in their most highly developed forms they were from the first recognized to be "eyes." Practically nothing has been made known as to the functional values of these organs, which in different genera occur in a great diversity of form, number, and arrangement. It has been shown, however, that the tegmental æsthetes of *Chiton tuberculatus* are indeed photosensitive (Arey and Crozier, 1919). But the shell-eyes are in this genus generally represented by structures of an intermediate degree of complexity. The "eyes" are supposed to have been derived from large, relatively undifferentiated shell receptors (macræsthetes), and seem to reach their highest development in those species of *Schizochiton* and *Tonica* which possess large complex eyes, each surrounded by a pigment cup (*cf.* Plate, 1899; Nowikoff, 1907, 1909); in *Chiton* (at least in some species of this genus) the eyes are "*intrapigmental,*" pigment being contained within the receptor cells, whereas with the "*extrapigmental*" eyes the associated pigment occurs outside

---

[1] Contributions from the Bermuda Biological Station for Research.

the receptor cells proper, in the integument. It seemed profitable to attempt an analysis of the functional values of the several types of photoreceptive elements to be found in different chitons. Accordingly, in 1918 I made observations on the photic irritability of representatives of several genera available at Bermuda. Pending the collection of more information on this subject, which is necessary for a full discussion of the problem here suggested, I give briefly the net result of these observations.

2. *Ischnochiton purpurascens*—found along the shores of islands in Great Sound, and in bays on the south shore of Bermuda, usually in more or less exposed situations, but commonly a little lower than the lowest reach of the tide (never between tidal limits)—is quite sensitive to light. Individuals about 1 cm. long were frequently obtained on bottles which had been on the bottom long enough to acquire a film of algal growth; the under surfaces of such bottles, and of smooth stones, provided most of my specimens. These animals were photonegative to light of any intensity used—from very weak diffuse light to direct sunlight. This species therefore resembles *I. magdalenensis* (Heath, 1899). It is said that among the *Ischnochitoninæ* there are no shell eyes. However, *Boreochiton*, also of this family, never occurs ''far from the light'' (Pelseneer, 1906, p. 50).

*I. purpurascens* is an active creeper (Crozier, 1919). It orients very quickly and precisely away from a source of illumination. At night its photic irritability seems decidedly enhanced, as I learned by comparing the rate of orientation of single individuals to lamp light, in a dark room, at different times during the twenty-four hours. (This would appear to be the case with *Chiton tuberculatus* also—*cf.* Arey and Crozier, 1919.) No evidence was had that *I. purpurascens* is reactive to changes of light intensity.

3. *Acanthochites spiculosus*. Specimens about 14 mm. long were found under stones, somewhat beneath low water level, in Ely's Harbor and at Spanish Point. In these places the water of the open ocean is less modified than within the sounds. The requirements of *Acanthochites* seems in this respect more rigorous than are those of the preceding species, for *A. spiculosus* was not found well within Great Sound. As in the case of *Ischnochiton*, the present species is decidedly photosensitive, and orients precisely away from the light. It moves faster away from a bright light than from a weak one, and comes to rest in the shade. It is strongly thigmotactic, tending to settle in the angles at the

corners of an aquarium, and once in such a situation is difficult to move by light. Negative geotropism is also fairly well pronounced.

If the intensity of light falling on an *Acanthochites* be suddenly increased, the girdle is depressed into contact with the substratum. Local illumination confined to the girdle leads to a local response of the same character. The shell plates seem not to be sensitive in this respect.

As in the case of most Chitons (Sampson, 1895; Crozier, 1919; Arey and Crozier, 1919), the body may be strongly curved to one side, the animal pivoting in a circle of short radius. Photic orientation is often accomplished in this way. The "pivoting" of *Acanthochites* ceases instantly when the creature is shaded; orientation is resumed when the light is increased. Since the girdle does not respond to shading of this part alone, I am led to believe that the shell plates are probably responsible for this type of reaction (as with *Chiton;* Arey and Crozier, 1919).

4. As elsewhere described (Arey and Crozier, 1919), the shell-plates of *Chiton tuberculatus* contain receptors activated by light of constant intensity and by shading.

5. An unidentified species of *Tonica,* about 6 mm. long, commonly obtained in company with *Ischnochiton purpurascens,* was found not to be reactive to shading, nor to increase of illumination; but, like the latter, was decidedly photonegative. This form is not so reactive to light as *Ischnochiton,* however.

6. Plate (1901) considered it possible that the order of evolution of the shell eyes of Chitons was from megalæsthetes to intrapigmental eyes to extrapigmental eyes. In the present series of species, this order would be represented by *Ischnochiton, Chiton,* and *Tonica,* in respective sequence. The shell eyes are of course not the only photoreceptors in these animals; for the girdle the ventral surfaces of the body (Arey and Crozier, 1919), and, possibly, the bilateral larval ocelli (Heath, 1904) are functional in this respect. But the experiments recorded in this paper show that functions of a certain diversity are served by the tegmental photoreceptors of the several species. Little can definitely be said, however, regarding the correlation of structural features with functional performance. It is noteworthy that members of the *Ischnochitoninæ*—a group characterized by the absence of shell "eyes" (*i.e.,* with megalæsthetes and micræsthetes only)—are quite as reactive to photic irritation as are members of *Chiton* proper, where, so long as the tegmentum is uneroded, eyes of the

intrapigmental type are functional; they are also more reactive than *Tonica* is, although in the latter extrapigmental eyes are developed. *Acanthochites,* moreover, likewise with intrapigmental "eyes," is reactive to shading, as in the case of *Chiton,* while *Tonica* is not. We are therefore unable to assign definite types of irritability to the several forms of shell photoreceptors.

The position taken by Nowikoff (1909), on morphological grounds, that these organs are not related in genetic sequence, is not inconsistent with such functional data as I possess. He regards the intra- and extrapigmental eyes as being independently derived from megalæsthete structures. It is possible to consider that the megalæsthetes (or certain of them) are activated by light, and that this kind of irritability is simply retained by eyes of the extrapigmental variety, whereas eyes of the intrapigmental sort are in addition activated by shading. However, the local activation of the girdle (of *Chiton*) by light and by shading makes it necessary to believe that tegmental mircæsthetes (*e.g.,* of the girdle scales) may also be implicated in the photic irritability of the shell-plates. As yet, experimental data for the analysis of this problem is incomplete. The possible significance of the number of shell-eyes present also needs to be investigated.

College of Medicine,
University of Illinois,
Chicago, 1919.

## PAPERS CITED

Arey, L. B., and Crozier, W. J.
1919. The Sensory Responses of *Chiton.*. *Jour. Exp. Zool.,* Vol. 29, pp. 157–260.

Crozier, W. J.
1919. On the Use of the Foot in Some Molluscs. *Ibid.,* Vol. 27, pp. 359–366.

Crozier, W. J., and Arey, L. B.
1918. On the Significance of the Reaction to Shading in *Chiton.* *Amer. Jour. Physiol.,* Vol. 46, pp. 487–492.

Heath, H.
1899. The Development of *Ischnochiton.* *Zool. Jahrb.,* Abt. Anat., Bd. 12, pp. 1–90.
1904. The Larval Eye of Chitons. *Proc. Acad. Nat. Sci.,* Philadelphia, 1904, pp. 257–259.

Moseley, H. N.
1885. On the Presence of Eyes in the Shells of Certain Chitonidæ and on the Structure of These Organs. *Quart. Jour. Micr. Sci.,* N. S., Vol. 25, pp. 37–60.

Nowikoff, M.
1907. Über die Rückensinnesorgane der Placophoren nebst einigen Bemerkungen über die Schale derselben. *Zeit. Wiss. Zool.*, Bd. 88, pp. 153–186.
1909. Über die Intrapigmentären Augen der Placophoren. *Ibid.*, Bd. 93, pp. 668–680.
Pelseneer, P.
1906. Mollusca, in Lankester, Treatise on Zoology, Part V, 355 pp. London.
Plate, L.
1899. Die Anatomie und Phylogenie der Chitonen (Theil B). *Zool. Jahrb.*, Suppl., Bd. 4 (Fauna Chilensis, 1. Bd.), pp. 15–216.
1901. *Idem.* (Theil C). *Ibid.*, Bd. 5, pp. 508–600.
Sampson, L.
1895. The Musculature of *Chiton*. *Jour. Morph.*, Vol. 11, pp. 595–628.

## THE BIONOMICS OF PORICHTHYS NOTATUS GIRARD

*Porichthys notatus* is a batrachoidid fish, which is known to range from southern Alaska to the Gulf of California, and from depths of at least 62 fathoms to just above the lower low-water level of the reefs. During the fall and winter months it inhabits comparatively deep water, where nothing definite is known concerning its life, beyond the fact, recorded by Dr. and Mrs. Eigenmann (1889, p. 132), that it is at least occasionally preyed upon by rock-cods (*Sebastodes*). In the late spring and early summer a shoreward migration apparently takes place (Greene, 1899). Along the coasts of Lower California and on the mainland shore of southern California, it is usually found in shallow bays at this season; at Santa Catalina Island Holder (Holder and Jordan, 1909) has mentioned hearing numbers just off rocky shores. There is but one record of the occurrence of the species in the reef-pools south of the vicinity of Pt. Conception in California, Hilton (1914) having found a specimen in a pool on the reef at Laguna Beach, California.

From Pt. Conception northward, on the contrary, this species, while never abundant is by no means rare along the reefs within tidal limits, during the breeding season. Here it occupies very shallow, often sandy pools, either those containing boulders or those with horizontal crevices in the rocky sides. It is here a fish of sluggish and retiring habits, swimming slowly with an undulating motion; when disturbed it usually seeks shelter, but sometimes swims off a short distance only, coming to rest and